REMARKS

This application is a nationalization of a PCT application under 35 U.S.C. §371. Amendments have been made to place the application in a better form for examination.

Claims 1-10 have been cancelled; claims 11-24 have been added. The claims have been rewritten to better express the subject matter being claimed. The specification has been amended, and due to the number of grammatical changes, a substitute specification has been prepared. No new matter has been added.

Claims 11-24 are pending.

The Applicants respectfully submit that the pending claims are allowable and look forward to the early issuance of a Notice of Allowance.

The Examiner is respectfully requested to contact the undersigned in the event that a telephone interview would expedite consideration of the application.

Respectfully submitted,

Craig A. Summerfield, Reg. No. 37,947
Attorney for Applicants

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, ILLINOIS 60610
(312) 321-4200

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AMPLIFIER ~~PROVIDED WITH~~HAVING A REGULATION SYSTEM CONTROLLED BY THE OUTPUT STAGE

TECHNICAL FIELD

[0001] This~~e~~ ~~invention~~ application relates to an amplifier with output-stage-controlled regulation and to a method for output-stage-controlled regulation of an amplifier.

BACKGROUND

[0002] Often, electrical amplifiers have a two-stage construction. In a first stage, an intermediate circuit generator or a power supply unit generates a supply voltage of medium ~~height~~ amplitude or precision. The supply voltage and intermediate circuit generator supply~~ies~~ an output stage ~~, which has the task of~~for generating an output signal with the desired properties. Depending on requirements, the output signal may have a voltage that is transformed upward compared to the supply voltage and, ~~depending on the application~~ may have predeterminable constant or time-dependent signal ~~courses~~properties. For use as a gradient amplifier for gradient coils in magnetic resonance systems, especially fast-time dependent output signal ~~courses~~ properties that must be adhered to precisely must be assured. ~~The electronics of the output stage can be adapted such that when supplied with the requisite supply voltage, an output signal with the desired properties can be generated, given the most efficient possible construction.~~

[0003] The precision with which the desired parameter values of the output signal, such as current or voltage, can be adhered to depends, among other factors, on fluctuations in the power supply voltage. Under some circumstances, fluctuations in the power supply voltage can be partly compensated for by ~~means of the~~ circuitry of the output stage. However, complete compensation is not always possible, and hence not all the requirements made of the output signal can readily be met.

[0004] With a view to the quality of the output signal, a stabilized power supply unit is ~~therefore~~ employed~~ as a rule~~. In addition, the desired parameters of

the output signal can be regulated, and the regulator, for instance, regulates switching times of switch elements of the output stage. Such regulation can be adapted optimally to the desired mode of operation of the output stage, so as to minimize the effects of a fluctuating supply voltage. Nevertheless, at critical operating points, for instance when the time-dependent ~~courses~~ properties of the output signal are changing rapidly, ~~it must be observed that~~ an influence of the power supply signal ~~is preserved~~remains. Depending on ~~the demands made of~~ the output signal requirements, additional compensation for supply fluctuations can therefore be desirable.

~~[0005] The object of the invention is, for a two-stage amplifier, to create an additional possibility of compensating for fluctuations in a parameter of the energy supply.~~

~~[0006] The invention attains this object with an amplifier having the characteristics of independent claim 1 and by means of a method having the characteristics of independent claim 10.~~

SUMMARY

[0005] ~~A fundamental concept of the invention is to disclose~~ Aan amplifier having an output stage which can be supplied by an electrical energy source, the output stage ~~is connected on the~~having an input ~~side to~~from a ~~a~~ control device ~~, by whose control signal~~for controlling an output signal~~, dependent on a parameter value of the energy source~~ is described~~, of the output stage is controllable. An output stage may also comprise a plurality of series-connected individual output stages, which are supplied from potential- free energy sources. For additional~~ ~~c~~Compensation for fluctuations in the energy source is provided by~~, a~~ a compensation device ~~is provided,~~ which is connected to the energy source and to the control device, and by which ~~the~~ a control signal is variable as a function of the value of the parameter. An output stage may also comprise a plurality of series-connected individual output stages which are supplied from potential-free energy sources.

~~[0008] The advantage of this construction is that~~ Ffluctuations in the energy source ~~need~~ may be ~~not first be detected in the output signal of the output stage in order to be capable then of being compensated. Instead, they are already~~ detected as they occur and before an output signal is generated. ~~Their~~ The effect of the fluctuations on ~~influence on the function of~~ the output stage performance is ~~already~~ taken into account in the control signal for the output stage, and therefore compensated for in advance, or ~~in other words~~ proactively. Therefore, ~~particularly~~ fluctuations at critical operating points, for instance when rapid changes in the output signal are occurring, which are often ~~connected~~ associated with ~~to~~ an ~~overswing~~ overshoot because of the ~~mode of operation of the~~ control of output stage, may be~~are~~ suppressed, without additional sources of error, such as the ~~aforementioned overswing~~ overshoot ~~being capable of~~ affecting the compensation. Thus, the compensation is effected in a way that is directly dependent on the signal to be compensated for and independently of other, unwanted, influencing variables.

[0006] ~~In a further feature of the invention~~In another aspect, a regulation system is provided which is connected on the input side to the output stage and ~~on~~ the output side to the control device, and by whose regulator signal the control signal can be regulated as a function of the output signal of the output stage. The regulation system is connected to the compensation device, and by means of the compensation device, the regulator signal is variable as a function of the value of the parameter of the energy source.

[0007] As a result, ~~the advantage is obtained that~~ the output signal of the output stage can initially be regulated as stably as possible by the regulation system, and ~~that~~ the compensation device accomplishes an additional stabilization. Combining the two devices brings about ~~especially reliable~~ stabilization of the output signal. In a further ~~advantageous feature~~aspect~~ of the invention~~, the compensation device is embodied ~~such that it can~~to generate a compensation signal that is dependent on the parameter and on a nominal or maximal value of the parameter. As a result, an operating range for the compensation signal is

predetermined such t~~t~~hat ~~stands in relation to the desired signal of the energy source and therefore maintains~~ an operating range ~~adapted~~ adapts to ~~it~~that of the desired signal of the energy source. As a result, for different nominal or maximal values of the energy source, an ~~overswing~~ overshoot from ~~an~~ ~~excessively great~~ variations in the compensation signal can be avoided.

~~[0011]~~ A ~~further fundamental concept of the invention comprises a~~ method for controlling an amplifier having an output stage which is supplied by an electrical energy source, includ~~ing the following steps~~es:

~~[0012]~~ providing an output stage connectable to an energy source; ascertaining a parameter value of the energy source (a first parameter value); ~~,~~

~~[0013]~~ generating a compensation signal as a function of the first parameter value~~,~~;

~~[0014]~~ generating a control signal as a function of the compensation signal; and ~~,~~

~~by means of the output stage,~~ generating an output signal as a function of the control signal.

[0008] ~~This has the advantage that~~

[0009] F~~f~~luctuations in the energy source can be directly detected and used for compensation. As a result, other~~,~~ indirect influencing variables, which may be due to the control or mode of operation of the output stage, ~~for instance, are not taken into account and cannot, as sources of error, have~~ may not have an effect on the compensation and the ~~.~~compensation ~~that~~ of the output stage is directly dependent on the energy source ~~brings about a stabilization of the output signals of the output stage~~.

~~[0017]~~ In ~~an advantageous feature of the method~~a further aspect, the method includes~~following further steps are included~~:

~~[0018]~~ ascertaining a parameter value (a second parameter value) of the output signal; ~~,~~

~~[0019]~~ ~~—~~generating a regulator signal as a function of the second parameter ~~value of the output signal~~; ~~,~~and,

[0010] generating the control signal as an additional function of the regulator signal.

[0011] The combination of the method steps for direct compensation of fluctuations in the energy source and for regulating the output signal of the output stage ~~brings about an additional, as it were double~~may further~~,~~ stabilizae~~tion~~ ~~of~~ the amplifier output signal.

[0012] The amplifier and the method, as a function of, for example, ~~-~~an energy source supply voltage, can generate an amplifier output voltage which is stabilized by the compensation device. The regulation system can also regulate the output voltage on the basis, for example, of the current induced in a coil by the output stage.

[0013] The ~~proposed~~ supply-voltage-dependent, output-current-regulated amplification ~~can~~ may be employed ~~especially advantageously as~~in a gradient amplifier for a gradient coil in a magnetic resonance system, where a coil current changes ~~or in other words gradients that must be adhered precisely must be generated~~ rapidly with time, ~~in rapid chronological succession~~ in order to generate rapidly changing magnetic gradient fields.

~~**[0024] Further advantageous features of the invention are the subject of the dependent claims and will become apparent from the description.**~~

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] ~~Exemplary embodiments of the invention are described in further detail below in conjunction with drawings. Shown are~~Fig. 1 illustrates a regulated two-stage amplifier with a compensation device;

[0015] Fig. 2 illustrates a regulated two-stage amplifier with a compensation device and a regulator signal amplification device;

[0016] Fig. 3 shows the relationship of the control signal of the output stage to the regulator signal;

~~:~~;

~~Fig. 1, a regulated two-stage amplifier with a compensation device;~~

~~Fig. 2, a regulated two-stage amplifier with a compensation device and a regulator signal amplification device;~~

~~[0025] Fig. 3, the course of the control signal of the output stage as a function of the regulator signal;~~

~~[0026]~~ Fig. 4~~,~~ shows the ~~the course~~relationship of the output signal of the output stage~~ as a function of~~ to the control signal;

[0017]

Fig. 5 is a ~~, the schematic construction~~block diagram of a PI regulator with D control and controllable regulation parameters;

[0018]

Fig. 6~~,~~ is a simplified schematic diagram ~~the digital construction~~ of a D regulating element; and

[0019]

[0020] Fig. 7 is a simplified block diagram of an I regulating element.

DESCRIPTION

[0021] ~~Fig. 7, the digital construction of an I regulating element.~~Exemplary embodiments may be better understood with reference to the drawings, but these examples are not intended to be of a limiting nature. Like numbered elements in the same or different drawings perform equivalent functions. When a specific feature, structure, or characteristic is described in connection with an example, it will be understood that one skilled in the art may effect such feature, structure, or characteristic in connection with other examples, whether or not explicitly stated herein.

[0022] Fig. 1 schematically shows a regulated two-stage amplifier 25 with a compensation device 9. The amplifier 25 has an electrical energy supply E_0, which supplies an output stage 6. The output stage 6 generates an output signal U_{out}, which is used to drive a load 8, shown here as a coil.

[0023] A parameter value of the output signal U_{out} is ascertained by a measuring device 7 and ~~is delivered~~applied to a regulation system 1 ~~via an actual value~~by a connection line 3.~~,~~ The value is noted ~~additionally followed~~ in the drawing by the letter A for "actual". As a further signal input, the regulation system 1 has a nominal value line 2, which is ~~additionally~~ noted ~~followed~~ in the drawing by the letter N for "nominal". The regulator signal RS is delivered to the control device 4 via a regulator output line 5, and the control device is connected to the output stage 6 via four signal lines (or correspondingly more in the event of a series circuit of ~~more~~ multiple output stages) for the control signals MS1 through MS_4.

[0024] The output stage 6 has a circuit arrangement with a smoothing capacitor, not identified by reference numeral, and four switches S_1 through S_4 and free-wheeling diodes, not identified by reference numeral, connected in parallel to ~~them~~the switches. The switches S_1 through S_4 are ~~triggered~~ operated by the control signals MS_1 through MS_4. As a result, an output voltage~~s~~ of the output stage 6 can be generated whose value, averaged over one switching period, can lie ~~be~~ between the positive power supply voltage $+U_0$ and the negative power supply voltage $-U_0$.

[0025] The power supply voltage U_0 is made available by ~~the~~ an energy supply E_0 and is therefore subject to fluctuations in the energy supply. As a consequence, the output signal U_{out} of the output stage 6 ~~is~~ may also be subject to these fluctuations.

[0026] To compensate for these fluctuations, a compensation device 9 is provided. ~~As its output signal, T~~The compensation device 9 generates a compensation factor k, or its reciprocal value 1/k as an output signal. The compensation factor k depends~~, in a manner to be described in further detail hereinafter,~~ on a parameter value of the energy supply E_0. ~~It~~The factor k is delivered to the regulation system 1 or the control device 4 via the compensator output lines 11 or 13, or the reciprocal value 1/k is delivered to the control device 4 via the compensator output line 14. The compensator output lines 11, 13, 14 are redundant in the sense that ~~all that is needed for~~only ~~compensation by the~~

~~compensation device 9 is~~ one of the three compensator output lines 11, 13, 14 is needed by the compensation device 9. In this sense, ~~they~~ the lines can be understood as alternatives to one another.

[0027] The amplifier 25 shown may generate an output voltage U_{out} which may be, for instance, ~~as~~ a function of a supply voltage U_0, ~~generate an output voltage Uout, which is~~and be stabilized by the compensation device 9. In th~~tha~~is aspect ~~case~~, the compensation device 9, ascertains the supply voltage U_0 as a parameter of the energy supply E_0. ~~, ascertains the voltage thereof, that is, the supply voltage U0.~~ By measuring the output stage supply voltage U_0, the voltage ex~~in~~cursions of the output stage, which may occur from a change in the load on the output stage, ~~are jointly~~may be compensated for as well. Moreover, the measuring device 7 ~~can~~ may be a current measuring device, which measures the current induced in the coil 8 by the output voltage U_{out} of the output stage 6. ~~This kind of~~Such a voltage-dependent, current-regulated amplifier 25 may be used, for instance, as a gradient amplifier in a magnetic resonance system, where ~~in~~ rapid ~~chronological succession~~time-dependent changes in the coil current, or ~~in other words~~ gradients, must be generated in order to ~~generate~~ produce rapidly changing magnetic gradient fields.

[0028] In another aspect, ~~In~~ Fig. 2 shows ~~,~~ an amplifier 26 ~~is shown,~~ with a modified compensation device 9 ~~that is modified compared to Fig. 1 described above~~. The output stage 6 with the regulation system 1 and the control device 4 correspond to the previous descriptions above and are identified by the same reference numerals. The compensation device 9 ~~likewise~~, as described above, generates a compensation factor k as a function of a parameter value of the energy supply E_0. The compensation factor k is delivered to a regulator signal amplification device 10 via the compensator output line 12. The regulator signal amplification device 10 is connected on the input side to the regulator output line 5, and ~~it~~ the amplification device 10 amplifies the regulator signal RS as a function of the compensation factor k~~K~~. In this way, the compensation device 9 acts on the controller of the output stage 6.

[0029] In Fig. 3, ~~the course of the~~ control signals MS_1 and MS_4 are~~is~~ shown as a function of the regulator signal RS. The regulator signal RS ~~is capable~~may ~~of~~ assume~~ing~~ values within an arbitrarily defined signal range from $-RS_0$ to $+RS_0$. The control device 4 may be an analog or digital modulator, which via the signals MS_1 through MS_4 triggers the switches S_1 through S_4 of the output stage 6, for instance in such a way that the switches S_1 and S_4 are opened or closed simultaneously, as are the switches S_2 and S_3.

[0030] In an analog modulator, the regulator signal RS is typically a voltage, which is compared in the modulator with a triangular voltage as a comparison variable. If RS is greater than the instantaneous value of the triangular voltage, then the signals MS_1 and MS_4, for instance, can be set for closing the switches S_1 and S_4. Conversely, if RS is less than the instantaneous value of the triangular voltage, then MS_2 and MS_3 can instead be set, so that the switches S_2 and S_3 are instead closed. In a digital modulator, the comparison variable may be a counter state. If the regulator signal RS, present in the form of a digital number, is greater than the counter state, then ~~once again~~ MS_1 and MS_4 ~~can~~ may be set, for instance, ~~be set,~~ while conversely if RS is less than the counter state, then MS_2 and MS_3 may~~can~~ be set instead.

[0031] If the switches S_1 and S_4 are closed and S_2 and S_3 are open, then the resultant output voltage U_{out} is the voltage $+U_0$; conversely, if S_2 and S_3 are closed and S_1 and S_4 are open, then the resultant output voltage U_{out} is the voltage $-U_0$. If the switches are opened and closed in alternation~~ after the modulation mode~~, the result, as an average value of the output voltage U_{out}, is a voltage which is between $+U_0$ and $-U_0$ and which depends on the switching times of the switches S_1 through S_4.

[0032] ~~The course shown for the regulator signal RS can accordingly mean~~ F~~f~~or instance, ~~that~~ at $-RS_0$, the signals MS_1 and MS_4 are not set, and the signals MS_2 and MS_3 are ~~not~~ set. As ~~By way of a linearly rising course with~~ the regulator signal RS linearly increases, the signals MS_1 and MS_4 as well as MS_2 and MS_3 are set and opened in alternation with modified switching times. For~~,~~ ~~while at~~ a

regulator signal of 0, the switching times for S_1 and S_4, ~~on the one hand,~~ and S_2 and S_3, ~~on the other,~~ are of equal length, ~~until then,~~and at a regulator signal of $+RS_0$, ~~now~~ only the signals MS_1 and MS_4~~1~~ are set, while MS_2 and MS_3 are not set.

[0033] In Fig. 4, the output signal of the output stage U_{out} is ~~plotted over the~~shown as a function of control signals MS_1 through MS_4. Based on the output signal $-U_0$ with the signal for MS_1 and MS_4 not set (~~in return,~~and MS_2, MS_3 are set at 100%).~~;~~T~~t~~he output signal ~~rises up to a value of~~is zero, when the switching times for MS_1 and MS_4, ~~on the one hand~~ and MS_2 and MS_3, ~~on the other~~ are of equal length. If the switching times shift further, such that only MS_1 and MS_4 are set, then the output signal rises further linearly, until the maximum value of $+U_0$ for the output signal U_{out} of the output stage 6 ~~U_{out}~~ is reached.

[0034] Together with the above description of the drawings, for the range of the regulator signal RS of from -RS0 to +RS0, a regulating range for the output signal U_{out} of from $-U_0$ to $+U_0$ thus results.

[0035] For the relationship among the control signals MS_1 through MS_4 and the regulator signal RS, the following equation applies:

$$MS_{2,3} = 100\% - MS_{1,4};$$

in this illustration, the control signals MS_1 through MS_4 are understood as a percentage of the time during which the respective control signal is set. In other words, at the value of 100%, for instance, MS_1 and MS_4 are constantly set, while at the value of 75%, for instance, they are set 75% of the time. If the regulator signal RS is added, then for the relationship between the control signals $MS_{1,4}$ and the regulator signal RS, the following equation applies:

$$MS_{1,4} = 50\% + RS * 50\% / RS_0.$$

For the relationship between the control signals MS1,4 and the output signal U_{out} of the output stage 6 ~~U_{out}~~, the following equation applies:

$$U_{out} = (U_0 / 50\%) * MS_{1,2} - U_0.$$

The amplification of the output stage 6 is obtained by inserting the above relationship for $MS_{1,4}$ into the preceding relationship for Uout:

$$U_{out} = (U_0 / 50\%) * (50\% + RS * 50\% / RS_0) - U_0,$$

and from the above, by ~~conversion~~simplification:

$$U_{out} = U_0 * RS / RS_0.$$

As a result, for the amplification V of the chain comprising the control device 4 and the output stage 6, the following equation is obtained:

$$V = U_0 / RS = U_{out} / RS_0.$$

[0036] The output signal U_{out} of the output stage 6 is thus linearly dependent on the regulator signal RS. However, there is also a dependency on the supply voltage U_0. In the event of a supply voltage U_0 that is not stabilized or is only insufficiently stabilized, for instance if fluctuations occur in the mains voltage or in the event of a rapidly varying load, an influence on the regulation properties may become~~s~~ apparent. This approach may be used with other modulation methods~~Since as a rule the goal of~~ where a modulation method is intended is to achieve a linear relationship between the output signal of an output stage and its regulator signal.~~,~~ ~~these concepts logically also apply to other modulation methods not described in detail.~~

[0037] From the preceding equation, it can be seen that compensation for fluctuations in the supply voltage U_0 is possible by ~~means of~~ a compensation factor k~~K~~, for which the following applies:

$$k = U_N / U_0,$$

where U_N represents a nominal or typical supply voltage, for instance the maximum supply voltage. For compensation, either the regulator signal RS is multiplied by the compensation factor k, or the range of the regulator signal is increased by factor 1/k, so that the range limits are at $RS_0 * 1/k$.

[0038] From the above-described Figs. 1 and 2, it can be seen that the compensation factor k, or its reciprocal 1/k, is delivered to either the regulation system 1, the control device 4, or the regulator signal amplification device 10.

[0039] In Fig. 5, as an example of a regulator included in Fig. 1, a PID controller with D control and adjustable controller parameters is shown. The nominal value N is delivered to a branch that has the D element 16, and the amplification of the D element 16 is adjustable by ~~means of~~ the D-signal amplifier 17. The D-signal amplifier 17, as its input signal, receives the compensation factor k, or a value proportional to the compensation factor k~~it~~, via the compensator output line 11. The amplified output signal of the D element 16, DS, is delivered to an adder.

[0040] The nominal value N is also delivered to a delay element DEL (delay), and from there it is delivered to a differentiator (DIFF). The differentiator DIFF ~~furthermore~~ receives the actual value A as its input signal and forms ~~the~~ a control signal as the ~~control~~ difference between the nominal value N and the actual value A. The control ~~difference~~ signal is delivered both to the adjustable P element 18 and to the I element 19 and from there to the I-signal amplifier 20. The adjustment of the P element 18 and of the I-signal amplifier 20 is also effected by the compensator output line 11, by way of which the compensation factor k or a value proportional ~~to it~~thereto is delivered. The P–signal PS and the I-signal IS, like the D-signal DS, are delivered to the adder SUM, which ~~from them~~produces ~~forms~~ the regulator signal RS. The ~~described~~ digital and adjustable PID controller 15 may be used as a regulation system in the ~~above-described~~ amplifier of Fig. 1 or Fig. 2.

[0041] The amplifiers 17, 18 and 20 for ~~required anyway for~~ adjusting the control parameters "P", "I" and "D" can be used ~~here~~ for adjusting the compensation factor as well, and the ~~making one additional~~ amplifier device 10 ~~is advantageously unnecessary~~may be omitted.

[0042] In an aspect, ~~In~~ Fig. 6 shows~~,~~ a ~~simple~~ digital construction for the D element 16 is shown. The nominal value N is delivered to an n-bit-wide memory, a D flip-flop D_{Flip}, and to an m-wide subtractor SUB. ~~Preferably~~In this example, let

m = n + 1. D_{Flip} is clocked ~~here~~ by the clock signal CLK, and the clock rate can be lowered by the signal CLK-$_{enable}$, for instance if CLK is ~~supposed to be~~ a high-speed system clock signal.

[0043] The rise response of the ~~described~~ digital D element, ~~on~~ with the condition that m = n + 1, ~~would be~~may shown in ~~tabl~~tabulare form as follows, for example:

Takt = "Clock signal".

Takt	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
N	0	0	2	4	6	8	8	8	8	8	6	4	2	0	0	0
Q		0	0	2	4	6	8	8	8	8	8	6	4	2	0	0
Out		0	2	2	2	2	0	0	0	0	-2	-2	-2	-2	0	0

[0044] In Fig. 7, a digital design of the I element 19 is shown. The input signal IN~~;~~ which, in a PID controller, ~~-~~is the control difference signal, is delivered to an adder ADD. The output signal of ADD is delivered to a D flip-flop D_{Flip}, which is clocked by a clock signal CLK and can be lowered in its clock rate by the signal CLK-$_{enable}$. The output signal Q of D_{Flip} is delivered to a further input of ADD. Thus the output signal of the adder ADD is at the same time the input signal of the amplifier 20. Alternatively, as the output, the output Q of D_{Flip} can be used, which in comparison to the output of ADD appears later by one clock signal. The ~~jump~~ response of the I element described can for instance have the following ~~appearance~~characteristics, assuming as a starting condition Q = 0:

Takt = "Clock signal".

Takt	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
N	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Q	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12
Out	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13

[0045] An analog integrator, ~~at~~ with a time constant corresponding to a clock signal length and an input voltage ~~that in~~ having the above-indicated time pattern, varies from zero to 1V, at a starting condition of 0V, ~~likewise~~ would have an output voltage which varies ~~with~~ by 1V per clock signal length, as in the above-indicated time pattern. As can be seen from these two examples, both analog and correspondingly constructed digital regulator circuits are substantially ~~fundamentally~~ equivalent in their functional principle and ~~in their regularities~~performance.

[0046] If the compensation is to be ~~done~~ performed by the compensation factor k, or its reciprocal, in the control device 4~~,~~ then, with a digital control device~~,~~ which has one or more analog-to- digital converters for converting an analog regulator signal RS, the multiplication of the regulator signal RS by the compensation factor k is ~~done~~ performed in the analog-to-digital conversion process. The ~~in that an~~ external reference input of one of the analog-to-digital converters is used for the standard of the conversion in accordance with 1/k. For a fully digital control device 4, the digital regulator signal RS can be multiplied by the compensation factor k. Alternatively, i~~I~~n an analog control device 4, ~~a favorable circuit variant can result by multiplying~~ the comparison variable (triangular voltage) may be multiplied by the reciprocal of the compensation factor;~~,~~ that is, 1/k. The compensator output line 14 described in conjunction with Fig. 1 ~~is~~ may be used.

[0047] ~~For the compensation factor k, in view of practical application of the amplifier,~~ L~~l~~imit values ~~can~~may~~-~~be specified for the compensation factor k. ~~-~~For instance, if the supply voltage U_0 ~~is~~ tend~~ings~~s toward zero, then the compensation factor k would tend toward infinity. Useful operation of the amplifier, however, is not possible at extremely low supply voltages U_0. A practical design could therefore be limited to supply voltages U_0 that, at maximum, are approximately 30% below the rated value of the supply voltage U_0 or approximately 40% above

the maximum value of the supply voltage. For supply voltages U_0 outside these limit values, the compensation factor k could then be kept constant.

[0048] In the description of the relationship between the output voltage of the output stage and the regulator signal, a linear relationship has been assumed ~~in~~ as an idealized form. Even if this ideal relationship does not in fact exist, for instance because of safety margins in the triggering of the output stage switches to avoid short-circuit triggering, the restriction to a useful operating range means that adequate precision of the compensation can still be achieved. ~~If not, then~~Alternatively, the nonlinearities can be taken into account in ascertaining k.

[0049] Although the present invention has been explained by way of the examples described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the examples, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

ABSTRACT OF THE DISCLOSURE

~~The invention relates to a~~An electrical amplifier comprising an output stage ~~(6)~~ that can be supplied by an electrical energy source, ~~and~~ is connected to a control device ~~(4)~~ on the input side, the control signal of the control device ~~enabling~~ controlling an output signal of the output stage ~~(6)~~ dependent on a parameter value of the energy source ~~to be controlled~~. The ~~inventive~~ amplifier is ~~provided with~~has a compensation device ~~(9)~~ that is connected to the energy source and the control device, ~~(4),~~ and is used to modify the control signal according to the parameter value of the energy source~~. The parameter~~ which can be, for example, the network voltage of the energy source. ~~The invention also relates to~~ A~~a~~ method for controlling an electrical amplifier comprising an output stage ~~(6)~~ supplied by an electrical energy source~~.~~ includes, ~~According to said method, a~~ determining parameter value of the energy source ~~is determined~~, deriving a~~a~~ compensation signal ~~is derived~~ therefrom, and a control signal for the output stage ~~(6)~~ is generated according to the compensation signal. The ~~electrical~~ amplifier and ~~the inventive~~ method can ~~advantageously~~ be used in a gradient amplifier for a magnetic resonance appliance.